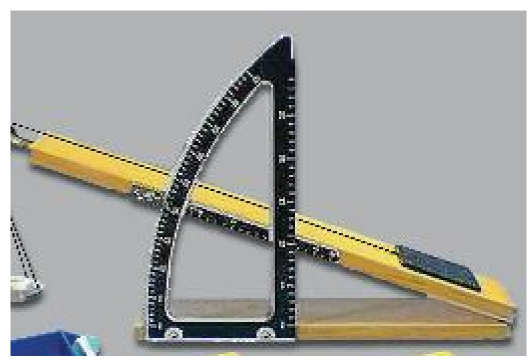
EXPERIMENT 12: COEFFICIENT OF FRICTION

PURPOSE:
investigate FRICTION and MEASURE THE COEFFICIENTS OF FRICTION

EQUIPMENT:
2 spring scale (1 with a max =1000g and one with a max =2000g), inclined plane (for example sergent welch WLS1812-21), friction box, masses (1kg, 500g, 2kg).



DATE______________

AUTHOR ____

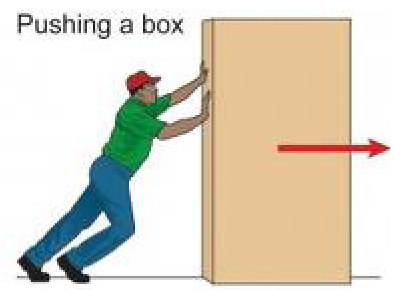
PARTNER _______________________________________

PARTNER _______________________________________

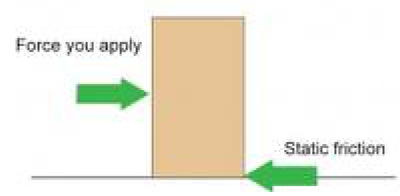
BACKGROUND

The friction force between an object and a surface depends only on the mass of the object and on the angle between the surface and the horizontal. When you push (or pull) an object, the **frictional force opposes the motion**. First, the object is not moving because the frictional force called the **static frictional force** exactly balances your push/pull

static frictional force = push/pull. As you push (harder) the static frictional force increases too to balance your push (pull).



The Box is not moving



STATIC FRICTION = PUSH

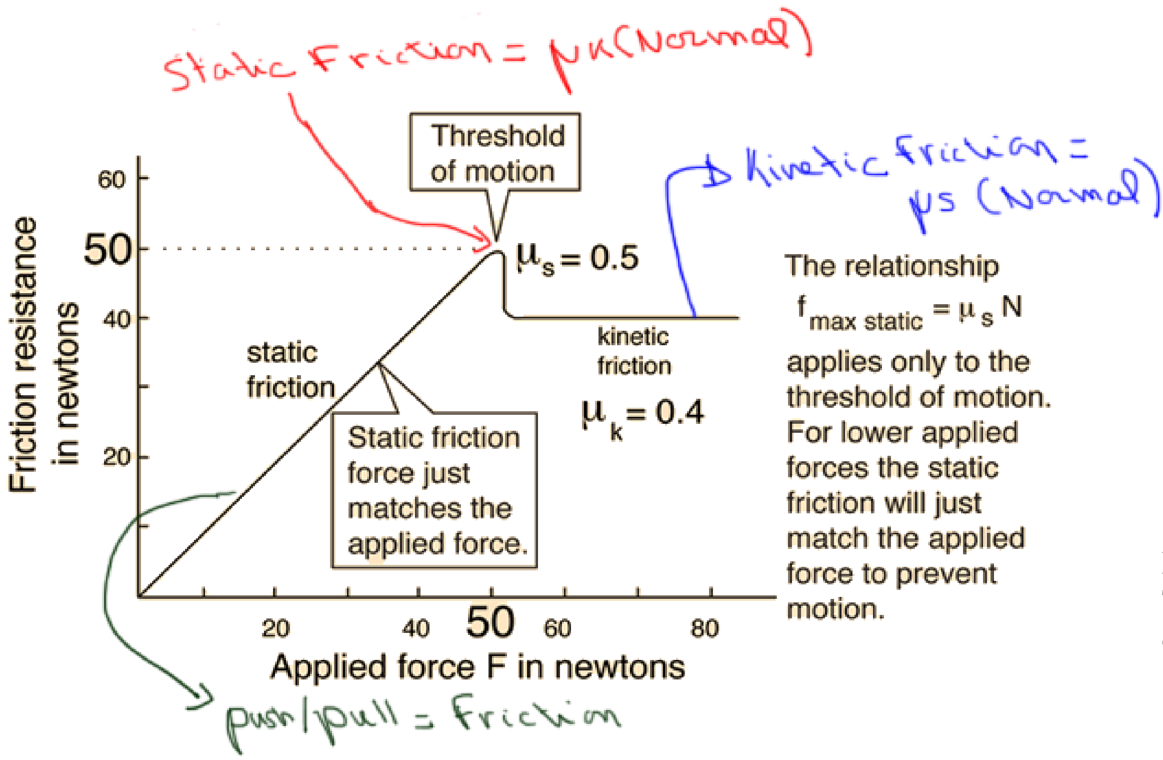
Finally, when the object is about to move you have the following equation:

Static frictional force MAX = µs Normal

µs is coefficient of static friction

the Normal is the " recoil force" between the surface and the object. The Normal is perpendicular to the surface. Once the object slides, the frictional force decreases and is called the kinetic frictional force.

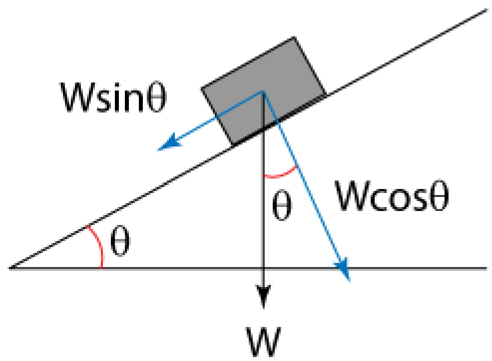
Kinetic frictional force = µk Normal **µk is coefficient of kinetic friction**



In the part I you will
The coefficients
depend only on the

material in contact (block and surface).

In part II you will use an inclined plane to compute the same coefficients.



When the plane has been tilted at a certain angle Θ with the horizontal, the object begins to slide down the inclined plane at a **constant speed**. Here are the 2 equations you get from static equilibrium.

(1) along X-axis **W sin(Θ) = kinetic friction**

The x-component of the weight is balanced by the frictional force.

(2) along the Y-axis **W cos(Θ) = Normal**

The y-component of the weigh is balanced by the recoil from the plane or Normal force.

And you also have a third equation. By definition:

(3) **Normal = µk kinetic friction**

"massaging" these 3 equations you get :

$$\mu k = \frac{W\sin(\Theta)}{W\cos(\Theta)} = \tan(\Theta)$$

PROCEDURE

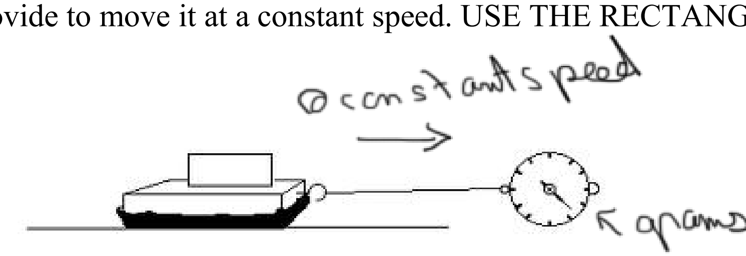
Your block is in wood and you will slide this block against your aluminum inclined plane The coefficients you will measure only depends on the material in contact: wood + aluminum,

PART 1

0. First check the spring scales to understand how the scale works. Count how many subdivisions you have to make sure you measure correctly the masses are the forces. For example. If you have 5 subdivisions between 400g and 600g that means each little step is 25g. All the measurements will be made in grams.

1. measure the mass (g) of the block using **<u>the rectangular spring scale</u>**. Mass block = _______ grams
2. Place a 1kg mass in the block. The total mass is now = _________ grams (1kg =1,000g). Report in TABLE 1

3. Your inclined plane is **flat.** Place the block at one end of the plane with the mass inside and measure in grams the force you need to provide to move it at a constant speed. USE THE RECTANGULAR SCALE.



This force is the kinetic frictional force measured in grams.
FRICTION = PULL if the block MOVES AT A CONSTANT SPEED.
Report your measurements in the table below.

TABLE 1: wood + aluminum / kinetic coefficient

Mass block (g)	Mass in the block (g)	Total mass (g) (col1 + col2)	Pull (g)= kinetic friction	Kinetic coefficient **µk** (col 4 / col 3)
	1000g			
	500g			
	2000g			

4. The coefficient of kinetic friction is defined as :

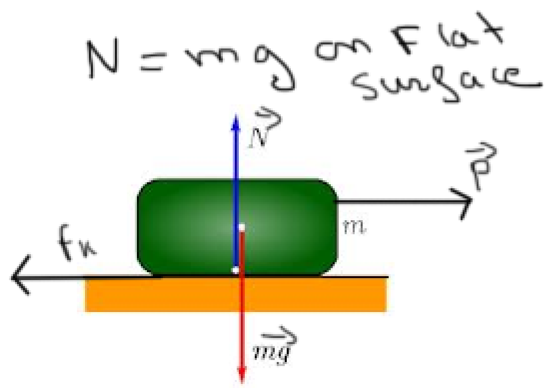
Kinetic frictional force = µk Normal

Since the surface is flat Normal = weight
and pull = frictional force so you get:

pull = µk weight

or µk = pull (grams) / weight (in grams)

Fill the last column by computing the coefficient.



5. Repeat the steps 1 to 4 for masses of 500g and 2000g.

6. **µk** should be about the same. Find the average **µk = _______ (no unit)**

7. USE THE ROUND SCALE. Now you will find the static coefficient. The block has 1000g inside and is at rest. While the block is at rest, pull the scale very slowly until you get the MAX PULL **before** the block moves. The pull should be larger than before. Report you measurement below.

TABLE 2: wood + aluminum / static coefficient.

Mass block (g)	Mass in the block (g)	Total mass (g) (col1 + col2)	Pull (g)= satic friction	Static coefficient **µs** (col 4 / col3)
	1000g			
	500g			
	2000g			

8. repeat for 500g and 2000g and fill the table,

9. **μs average = ______________**

part II : The inclined plane.

1. Place the block with the 1000g mass inside on the incline plane. At one end. The mass is centered.
2. Increase the angle slowly until the block slides.

Very carefully determine that angle. Do it several time. It should be larger than 20 degrees.
(there is a protractor attached to the plane).

Report in the table:

TABLE 3: inclined plane

Total mass (g) mass + block	Angle for static	**μs =tan(angle)**	Angle for sliding	**μk=tan(angle)**

3. Repeat for the other masses.

4. Compute the static coefficient = tan(angle). Fill col3.

5. Find the average **μs = ______________**

6. Move the object to one end of the board. Again, slowly lift this end of the board while your lab partner lightly taps the object. Adjust the angle of the board until the object slides at a constant speed after it has received an initial tap. Use the protractor to measure this angle and record in Table 3 as the angle of sliding (kinetic) friction. The tangent of this angle is the coefficient of sliding friction. Report in TABLE 3.

7. Repeat for the other masses.

8. Find the average **μk = ______________**

ANALYSIS

1) Compare the static friction coefficients for Part 1 and Part II. They are supposed to be the same .
Compute the % discrepancy.

2) Compare the kinetic coefficients for part I and part II. They are supposed to be the same.
Compute the % discrepancy.

3) Compare the kinetic coefficients to the static coefficients. Are they the same ?

4) A block is on a flat surface and is pulled at a constant speed. Make a free-body diagram and show all the forces acting on the block. Write the static equilibrium equations along the X-axis (1) and along the Y-axis(2) and show that : coefficient = weight / normal . Use the definition : **friction force = coefficient x normal**

6) Now the block is sliding at a constant speed on the inclined plane. Make a free-body diagram and show all the forces acting on the block. Draw the components of the weight.
Write the 2 equations of equilibrium.

Use the equations and the definition **friction force = coefficient x normal** to show:
coefficient = tan(angle of plane).

CONCLUSION:
Was the purpose of this lab accomplished ? Why or Why not ?
(your answer to this question should show thoughtful analysis and careful, through thinking)